Project Report: Planetary Biology, Evolution and Intelligence

Project Investigators:	***Peter Backus , Emma Bakes , Amos Banin , Max Bernstein , Janice Bishop , Nathalie Cabrol , Chris Chyba , Edna DeVore , Friedemann Freund , Edmund Grin , Bishun Khare , Rocco Mancinelli , Cynthia Phillips , David Summers , Jill Tarter , Lynn Rothschild***

Project Progress

Friedemann Freund and Lynn Rothschild are investigating oxidation driven by diffusive loss of hydrogen formed within igneous and metamorphic rocks. New data include the observation of oxygen evolution from magnesium oxide crystals.

Emma Bakes is completing a paper describing the chemical foundations of nitrogenated macromolecules in Titan's haze. This work is complemented by laboratory work by Bishun Khare and Hiroshi Imanaka.

Janice Bishop and Rothschild have measured ultraviolet (UV), visible, and infrared (IR) spectra for iron–oxide–bearing samples, and experiments have been performed on cultures of two photosynthetic microorganisms. Data indicate that certain ferric–oxide–bearing minerals could have provided protection from UV radiation on early Earth.

Nathalie Cabrol and Edmond Grin have led a series of investigations of high–altitude lakes to examine the strategies employed by their microorganisms. The group they lead is currently analyzing data from its 2003 expedition. Discoveries include an active community of modern stromatolites and the culture and phylogenetic characterization of apparently new bacterial species.

Amos Banin has begun the analysis of soil samples from the Atacama Desert. Rocco Mancinelli and Banin are experimentally investigating whether binding of N as NH_4+ in silicate minerals could account for the “missing” N on Mars.

David Summers and Bishun Khare have begun experimental work on the abiotic fixation of nitrogen under atmosphere expected on early Mars.

Cynthia Phillips and Christopher Chyba are completing a major project, using Galileo imaging of Europa, to quantify the impact cratering “gardening” rate on Europa.

These results will be coupled with the results of low−temperature laboratory experiments. Mr. Kevin Hand, in collaboration with Robert Carlson and Chyba, is pursuing this research at JPL. Over the past year, Hand and Carlson have constructed the irradiation apparatus and have experiments underway.

Max Bernstein, in his lab at NASA Ames, has measured the mid−IR spectra of several polycyclic aromatic nitrogen heterocycles.

Peter Backus, Jill Tarter, Mancinelli, and Chyba have begun their examination of the prospects that planets orbiting dwarf M stars are habitable for either microscopic or complex life.

Finally, education and public outreach are major and integral parts of the work of the SETI Institute's NAI team. They are addressed elsewhere in our first−year summary, so are not presented here.

Highlights

- An active community of modern stromatolites producing limestone and developing in the highly saline shallow (50 cm) Laguna Blanca was discovered. From our 2003 reconnaissance, we believe that this community covers the entire floor of the lake (3 km x 1 km).
- The successful culture and phylogenic characterization in laboratory of two isolates from Laguna Blanca are determined to be two new species of the genus *Pseudomonas* and *E. Coli* . (analysis in progress).
- Ongoing characterization of the three lakes microbial communities and ecosystems details can be provided upon request.
- Diatoms (*Haslea*) developing UV shielding strategies (mucilaginous knobs and mesh) have been observed.
- Percentages of malformation and deformities are 10% higher than standard count in other lakes.
- Successful surface, subsurface, and subaqueous sampling (through diving and plankton netting) of water, life, and sediment in the lakes at 6,014 m and 4,430 m was performed.
- An Eldonet UV Dosimeter measuring ultraviolet A (UVA), ultraviolet B (UVB), photosynthetically active radiation (PAR) and Temperature was positioned at the Licancabur summit lake. The dosimeter is now the highest of its kind in the world and will record a year’s worth of data at 6,014 m. Because of its geographical position, it may also record the advances of the Antarctic ozone hole in this region of the Andes. Another identical dosimeter was positioned on the shore of Laguna Blanca as well as 7 UV acrylite plate stations. The underplate of these stations (each composed of one UV transmitting and one UV blocking plate) will be sampled in the coming years to study the effects of UV on immobile periphyton.
- Data of water temperature profiles (one year's worth) were collected and chemical analysis of the water for all lakes was performed. Laguna

Verde seems to be a very close analog to the Meridiani Planum paleo aqueous environment explored by the rover Opportunity. We report comparable levels of sulfate, bromine and chlorine. Carbonates are present in that lake, but they have not been identified on Mars.
- First Mapping and sonar sounding of Laguna Verde was performed, and sonar mapping of the Licancabur summit lake was initiated.
- Investigation continues to determine if the Atacama Desert soil is a real Mars soil analog.
- The missing nitrogen on Mars may be hidden as fixed ammonium in the Mars soil and regolith.
- There is a suggested possibility that early photosynthetic organisms may have existed in small niches protected by ferric–oxide–bearing material.
- A list of potential workshop participants has been compiled.
- The first star catalog of 2.5 million stars has been obtained.

Roadmap Objectives

- ***Objective No. 1.2:*** Indirect and direct astronomical observations of extrasolar habitable planets
- ***Objective No. 2.1:*** Mars exploration
- ***Objective No. 2.2:*** Outer Solar System exploration
- ***Objective No. 3.1:*** Sources of prebiotic materials and catalysts
- ***Objective No. 4.1:*** Earth's early biosphere
- ***Objective No. 4.2:*** Foundations of complex life
- ***Objective No. 5.1:*** Environment–dependent, molecular evolution in microorganisms
- ***Objective No. 5.3:*** Biochemical adaptation to extreme environments
- ***Objective No. 6.1:*** Environmental changes and the cycling of elements by the biota, communities, and ecosystems
- ***Objective No. 6.2:*** Adaptation and evolution of live beyond Earth
- ***Objective No. 7.1:*** Biosignatures to be sought in Solar System materials
- ***Objective No. 7.2:*** Biosignatures to be sought in nearby planetary systems